

**CO₂-PROCESSES PHOTORESISTS, POLYMERS, AND
PHOTOACTIVE COMPOUNDS FOR MICROLITHOGRAPHY**

5 Cross-Reference to Related Applications

The present application claims priority to Provisional Application Nos. 60/239,749, filed October 12, 2000 and 60/267,993 filed February 9, 2001, the disclosures of which are incorporated herein by reference in their entirety.

10 Field of the Invention

The invention generally relates to processes relating to forming microelectronic devices using carbon dioxide.

15 Background of the Invention

There are a number of lithography processes which are well known in the art used in conjunction with manufacturing microelectronic devices. A typical lithography process involves aligning and transferring a pattern from a template using optics onto a partially processed substrate (e.g., wafer) that has been coated with a photoresist. The resist is then developed and the resist image is thereafter transferred into the underlying material typically by a chemical and/or thermal step such as, for example, dry/wet etch, sinter, implant, etc. This process is often repeated many times (e.g., between 15 to 20) during the course of building a complex integrated circuit.

The above processing steps can result in distortions being present in the wafer. Thus, wafer handling during processing is extremely important.

The wafer handling subsystem is believed to be largely responsible for the throughput of the processing tool. Accordingly, the wafer handling should be designed to minimize sources of possible contamination. A difficulty from a processing standpoint relates to the incompatibility of an organic or aqueous solvent based coating solution and the enclosed equipment (e.g., a vacuum environment) used for processing substrates that have developed photo resist images (positive or negative) formed therein.

U.S. Patent No. 5,665,527 to Allen et al. proposes a process for generating a negative tone resist image comprising the steps of coating a substrate with a film of a polymeric composition comprising a polymer, a photosensitive acid generator, and acid labile groups, imagewise exposing the film to radiation to generate free acid, and developing the image with critical fluid, e.g., carbon dioxide.

Notwithstanding the above, there is a need in the art for processes for forming semiconductor devices that involve depositing, developing and stripping resists that may be carried out in an integrated closed system which uses a solvent which is relatively benign from an environmental perspective (e.g., carbon dioxide). Such a process would be highly advantageous in that it would reduce or obviate the repeated entry, removal, and re-entry steps that are inherent in non-integrated processes.

Summary of the Invention

In one aspect, the invention provides a process of forming a resist image in a microelectronic substrate. The process comprises the steps of contacting the substrate with a first composition comprising carbon dioxide and a component selected from the group consisting of at least one polymeric material, at least one monomer, at least one polymeric precursor, and mixtures thereof to deposit the component on the substrate and form a coating thereon, then imagewise exposing the coating to radiation such that exposed and unexposed coating portions are formed, and then subjecting the coating to a second composition comprising carbon dioxide such that either one of the exposed or the unexposed coating portions are removed from the

substrate and the other coating portion remains on the coating to form an image thereon (e.g., developing the image using carbon dioxide). For the purposes of the invention, the first and second compositions may be the same or different. In a preferred embodiment, each step may be performed in a closed system such that said process is an integrated process. For the purposes of the invention, the term "closed system" refers to a system that is not exposed to ambient conditions.

This and other aspects are described by the invention in greater detail herein.

Detailed Description of the Preferred Embodiments

The invention will now be described in greater detail in reference to its preferred embodiments described in the text below and in the drawings. It should be understood that these embodiments are for illustrative purposes only, and do not limit the scope of the invention as defined by the claims.

Stated alternatively, the invention encompasses a method of forming a patterned resist layer on a substrate comprising the steps of forming on the substrate a resist layer comprising a material selected from the group consisting of at least one polymeric material, at least one monomer, at least one polymeric precursor, and mixtures thereof, by contacting the substrate with a first composition comprising the material and carbon dioxide, developing portions of the resist layer, and selectively removing developed or undeveloped portions of the resist layer by exposing the resist layer to a second composition comprising carbon dioxide.

Various substrates can be used for the purposes of the invention such as, for example, substrates which may comprise any number of materials including, but not limited to, silicon, ceramics, polymer, gallium arsenide, silicon carbide, or the like, and combinations thereof. In various optional embodiments, at least one intermediate layer (e.g., a silicon dioxide layer) may be present between the substrate and the coating.

The step of contacting the substrate which results in the formation of a coating thereon may be carried out using various techniques. Examples of